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Age of granitoid magmatism in South Georgia and correlations to southern Patagonia and the northern Antarctic Peninsula

Teal R. Riley [a,*], Andrew Carter [b]

[a] British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, UK
[b] Department of Earth and Planetary Sciences, Birkbeck, University of London, Malet Street, London, WC1E 7HX, UK

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ABSTRACT

South Georgia forms one of the most isolated fragments of continental crust on Earth and lies in a remote location in the southern Atlantic Ocean. Its geology is dominated by Early Cretaceous back-arc turbidite successions that are in faulted contact with a late Palaeozoic – early Mesozoic accretionary complex. The accretionary complex includes fragments of a deformed accretionary prism and ophiolite that are intruded by a suite of granitoid plutons that are dated here. Granitoid magmatism has been identified from the Middle Jurassic (c. 163 Ma) and Late Cretaceous (c. 107 Ma, c. 86 Ma), which can be correlated with convergent margin magmatism from the southern (Fuegian) Andes and Cordillera Darwin of southern Patagonia, and the northern Antarctic Peninsula, with the Late Cretaceous magmatism restricted to the western parts of each area. These correlations support earlier findings that established a contiguous relationship between the southeast sector of South Georgia and southernmost Patagonia (south of the Magallanes fault zone) and the northern sector of Graham Land (Antarctic Peninsula).

1. Introduction

South Georgia is a remote island in the southern Atlantic Ocean, situated 1700 km to the east of southern South America (Fig. 1a). The island forms part of the long-lived strike-slip system termed the North Scotia Ridge (Fig. 1b), which also defines the plate boundary between the South American and Scotia plates (Livermore et al., 1994). The North Scotia Ridge consists of several, mostly submerged, crustal blocks that form a linear chain from Tierra del Fuego to South Georgia. The overwhelming consensus (e.g. Carter et al., 2014; Riley et al., 2019; Dalziel et al., 2021; Beaver et al., 2022) is that from at least the late Mesozoic until the Eocene, the crustal block (microcontinent) of South Georgia formed a continuation of the Andean Cordillera (Fuegian Andes) until translation to its current location during the post-Eocene opening of the Scotia Sea. Dalziel et al. (2021) and Beaver et al. (2022) highlighted the striking similarities between the sedimentary and ophiolite successions of Tierra del Fuego and South Georgia, and proposed that South Georgia originated in the Staten Embayment (Fig. 1b). These correlations are supported by detrital zircon provenance analysis of sedimentary successions from South Georgia, Fuegian Andes and the North Scotia Ridge (Barbeau et al., 2010; Carter et al., 2014; Riley et al., 2019). More recent analysis by Riley et al. (2026) determined that South Georgia may have occupied a pre-translation position adjacent to both the Cordillera Darwin (Tierra del Fuego) and the northern Antarctic Peninsula prior to closure of the Rocas Verdes Basin (Fig. 2).

However, a fundamental problem with a contiguous relationship between Tierra del Fuego and South Georgia during the Late Cretaceous is that analysis of seafloor spreading along the West Scotia Ridge (Fig. 1b) can only accommodate approximately half of the translation required to account for the post-Eocene separation between Tierra del Fuego and South Georgia (Eagles, 2010). Dalziel et al. (2021) also acknowledged that the Scotia Sea tectonic history could not fully explain the present-day location of South Georgia and suggested that 'escape tectonics' during the Late Cretaceous along transcurrent faults may have also played a role.

We examine the U-Pb geochronology of a suite of granitoids from southeast South Georgia and from the islands to the west (Fig. 3) in an attempt to better understand the chronology of granitoid magmatism across South Georgia and help constrain the relationship to southern Patagonia. We will then test the paleo-reconstruction model (Fig. 2) of Riley et al. (2022, 2026) and investigate connections to the chronology

* Corresponding author.
E-mail addresses: trr@bas.ac.uk (T.R. Riley), a.carter@ucl.ac.uk (A. Carter).

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of granitoid magmatism in the Cordillera Darwin and the northern Antarctic Peninsula.

2. Geological setting

The lowermost successions of South Georgia are restricted to the southeast sector of the island (Fig. 3) and are composed of two distinct units separated by a fault trending NW-SE along the length of Drygalski Fjord (Stone, 1982; Macdonald et al., 1987). The Drygalski Fjord Complex was defined by Storey (1983) and is characterised by a suite of highly deformed metasedimentary rocks and paragneisses, and associated migmatites, that are intruded by multiple mafic-intermediate plutons, leading to localised hornfels texture (Storey, 1983). The Drygalski Fjord Complex has three spatially distinct metasedimentary successions

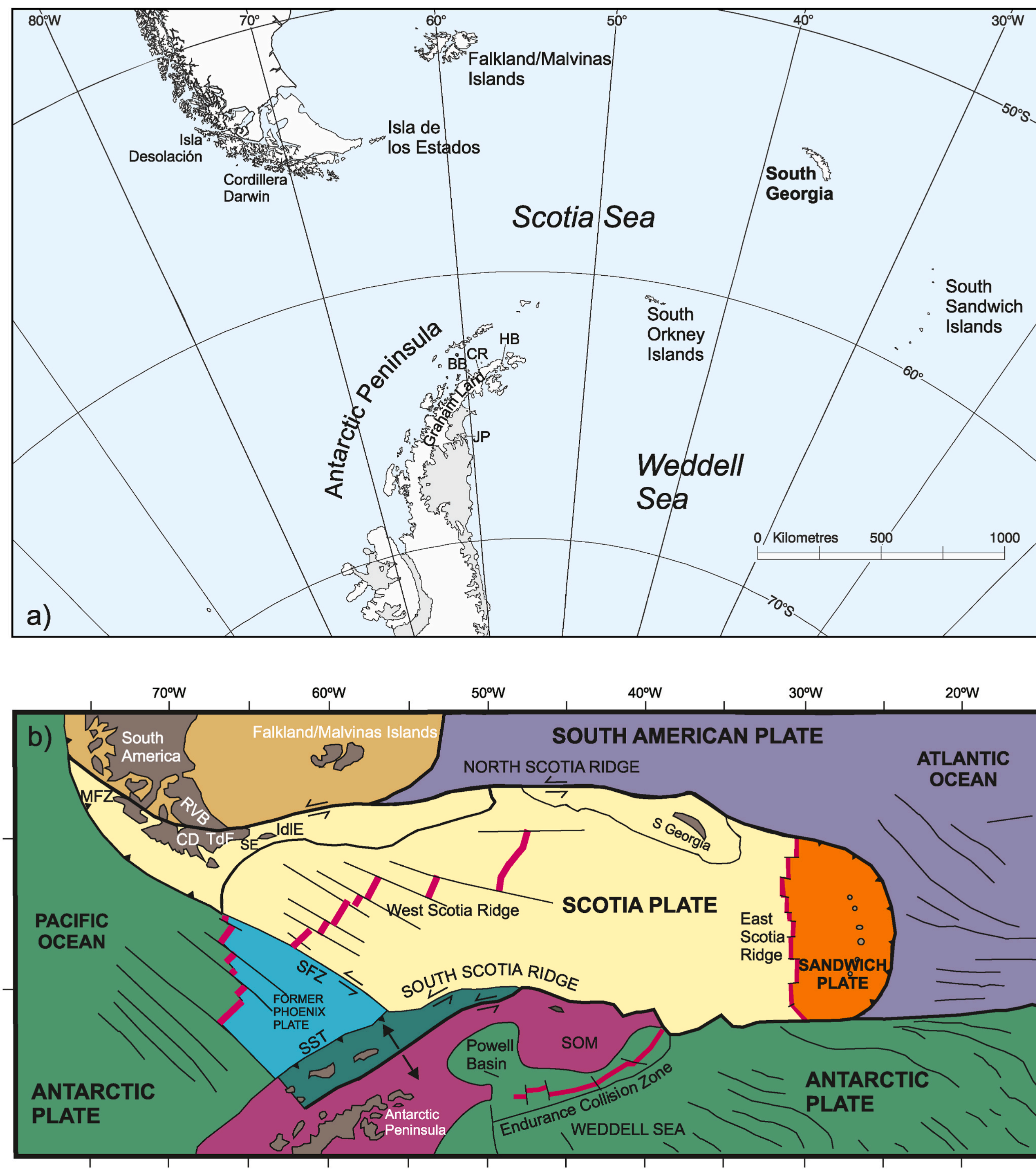

Fig. 1. a) Map of the Scotia Sea region and location of South Georgia. BB: Bone Bay; CR: Cape Roquemaurel; HB: Hope Bay; JP: Jason Peninsula. b) Tectonic setting of the Scotia Sea (adapted from Riley et al., 2022). TPG, Trinity Peninsula Group, CDMC, Cordillera Darwin metamorphic complex, CD: Cordillera Darwin; MFZ: Magallanes Fagnano fault zone; RVB: Rocas Verdes Basin; SE: Staten Embayment; IdlE: Isla de los Estados (Staten Island); SFZ: Shackleton Fracture Zone; SST: South Shetland trough; TdF: Tierra del Fuego; SOM: South Orkney microcontinent.

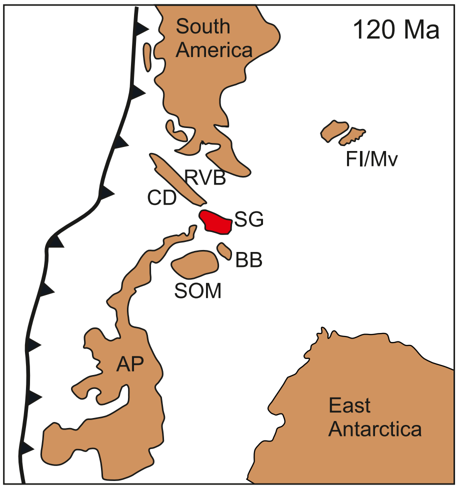

Fig. 2. Mid-Cretaceous paleogeographic reconstruction of West Gondwana showing the location of crustal blocks relative to South America and the Antarctic Peninsula. Adapted from the GPlates-derived kinematic reconstruction from Riley et al. (2022). RVB: Rocas Verdes Basin; CD: Cordillera Darwin; FI/Mv: Falkland/Malvinas Islands; SG: South Georgia; BB: Bruce Bank; SOM: South Orkney microcontinent; AP: Antarctic Peninsula.

that can be identified from the Salvessen Range, Cooper Island and adjacent to Drygalski Fjord (Fig. 3). These units are termed the Salomon Glacier Formation, Novosilski Glacier Formation and Cooper Island Formation (Fig. 3) and are considered as equivalents and components of the broader Drygalski Fjord Complex (Dalziel et al., 2021). The age of deposition of the metasedimentary rocks of the Drygalski Fjord Complex is Late Permian, with possible Early Jurassic accretion (Riley et al., 2026). The entire metasedimentary succession is intruded by plutons of Early – Middle Jurassic age (Tanner and Rex, 1979; Curtis et al., 2010), including plutons of anatectic origin (Tanner and Rex, 1979).

Situated to the west of the Drygalski Fjord Complex is the Larsen Harbour Complex, which has been interpreted as an incomplete ~2 km ophiolite sequence that consists of tholeiitic pillow basalts, massive lavas and intercalated chert, with the succession cut by multiple mafic dykes (Mair, 1987). The Larsen Harbour and Drygalski Fjord complexes were together interpreted as a Gondwana margin accretionary complex that was subject to crustal thinning during the Late Jurassic (Mukasa and Dalziel, 1996).

The majority of South Georgia's geology is dominated by two laterally equivalent Early Cretaceous turbidite sequences that were deposited into a back-arc basin (Fig. 3). These successions are the extensive Cumberland Bay Formation and the more restricted Sandebugten Formation, which are separated from the basement units by the Cooper Bay shear zone (Fig. 3; Curtis et al., 2010). The Cumberland Bay Formation has a thickness of up to 8 km and consists of volcaniclastic greywackes of andesite composition and has been deformed into large-scale folds associated with low-grade regional metamorphism (Stone, 1980). The succession is host to a probable Early Cretaceous (Aptian) fossil (ichnofauna) assemblage (Macdonald, 1982). The adjacent Sandebugten Formation is more siliciclastic and was inferred by Dalziel et al. (1975) to be derived from the continental margin and forms a quartz-rich sandstone and shale turbidite sequence. A likely facies equivalent of the Sandebugten Formation is the Ducloz Head Formation (Fig. 3) consisting of massive volcaniclastic breccias and interbedded tuffs. Another potentially related metasedimentary succession has been identified as the Cooper Bay Formation (Fig. 3) and is restricted to the southeast corner of the island and is a likely facies variation of the Cumberland Bay Formation (Clayton, 1982).

Plutonic rocks are the focus of this study and are limited in their areal extent across South Georgia, with the main concentration cropping out in the southeast of the island at Cooper Bay, Larsen Harbour, Smaaland Cove, and also the outlying islands to the west (Fig. 3). Many of the granitoid plutons are of uncertain age, but a small selection of U-Pb ages (Mukasa and Dalziel, 1996; Curtis et al., 2010) from South Georgia have yielded Middle – Late Jurassic ages from the Cooper Bay shear zone, Larsen Harbour Complex and Smaaland Cove intrusive suite. Earlier geochronology by Tanner and Rex (1979) yielded Rb-Sr and K-Ar ages from the Early Jurassic to mid-Cretaceous, but with concerns over reliability (Mukasa and Dalziel, 1996).

Volcanic arc rocks are restricted to Annenkov Island, Hague Reef and Pickersgill Islands (Fig. 3) to the west of South Georgia. The units exposed are distinct to the lithologies of the main island and have remained at a shallow depth since their emplacement (Carter et al., 2014). The Annenkov Island Formation is formed of andesitic tuffs and breccias that have a total thickness of almost 2 km (Pettigrew, 1981) and are probably Cretaceous in age (Tanner and Rex, 1979; Dalziel et al., 2021).

3. Previous geochronology - granitoids

The most extensive analysis of the age of magmatism on South Georgia was carried out by Tanner and Rex (1979) who examined >20 samples from a range of volcanic and plutonic lithologies. They mostly conducted K-Ar mineral geochronology (19 samples) but also dated three samples using Rb-Sr whole rock geochronology. They identified episodes of magmatism from the Cretaceous (c. 80 Ma, c. 127 Ma) and Early Jurassic – Late Triassic from across the Drygalski Fjord Complex, Smaaland Cove and outlying islands to the west of South Georgia. Tanner and Rex (1979) recorded ages from the Trendall Crag (Figs. 3 and 4) granite/granodiorite intrusion of 181 ± 30 Ma (Rb-Sr), 186 ± 9 Ma (K-Ar) and 201 ± 7 Ma (K-Ar), and correlated these with a Gondwanian episode of magmatism. They recorded an Early Cretaceous age (127 ± 4 Ma; Rb-Sr) for the Smaaland Cove tonalite, which they regarded as an upper age limit for the Larsen Harbour Complex.

Elsewhere on South Georgia, Tanner and Rex (1979) dated multiple samples from Annenkov Island, Hague Reef and Pickersgill Islands (Fig. 3). K-Ar dating from Annenkov Island yielded ages in the range 100–103 Ma from andesite lavas, with granitoids from Hague Reef (c. 92 Ma) and Pickersgill Islands (c. 87 Ma) yielding Late Cretaceous K-Ar ages. These ages are broadly consistent with the apatite fission track ages of Carter et al. (2014) which record long (>14 μm) mean lengths and indicate long term residence at near surface temperatures.

Mukasa and Dalziel (1996) questioned the accuracy of the Tanner and Rex (1979) dataset, particularly the Smaaland Cove tonalite age that was based on a two-point isochron. Mukasa and Dalziel (1996) dated (U-Pb) two samples from the Smaaland Cove intrusive suite that yielded a well-defined age of 150 ± 1 Ma, providing a revised upper age limit for the Larsen Harbour Complex.

The only other U-Pb zircon geochronology from South Georgia was undertaken by Curtis et al. (2010) who dated two granitoid samples from within the Cooper Bay shear zone (Fig. 3) to provide a maximum age constraint on deformation in the Drygalski Fjord Complex. Both samples yielded ages of 160 ± 1 Ma, with inherited cores also indicating an earlier event at 186 ± 3 Ma.

4. Sample selection

Six granitoid samples were selected for U-Pb analysis from the southeast sector of the island and from the outlying islands to the west of South Georgia (Fig. 3), which combined with the distribution of existing geochronology provides a comprehensive coverage of intrusive magmatism across South Georgia.

Sample M.1653CMB2.1 is a leucocratic medium-grained tonalite from northwest Cooper Island (Fig. 3). Cooper Island lies off the southeast coast of South Georgia, adjacent to Cooper Bay (Fig. 3). The geology of Cooper Island is dominated by siliciclastic metasedimentary rocks of the Cooper Island Formation and granitoids of uncertain age that intrude the metasedimentary lithologies. The Cooper Island Formation forms a sequence of inverted, laminated mudstones and massive sandstones (up to 5 m in thickness) that exhibit low-grade regional metamorphism and recrystallised to banded hornfels adjacent to the multiple intrusive bodies. The sedimentary rocks are likely to lie on the inverted limb of a regional scale fold (Storey, 1983). The dominant intrusive body on Cooper Island is a leucocratic granitoid that crops out over 5 km^2 and was referred to as the Cooper Island granophyre by Storey (1983). The granophyre is classified as a leucocratic tonalite and is the unit sampled for analysis here.

Samples M.1804.1 and M.4137.3 are granitoids from Trendall Crag (Fig. 3), adjacent to Drygalski Fjord that have been selected for zircon U-

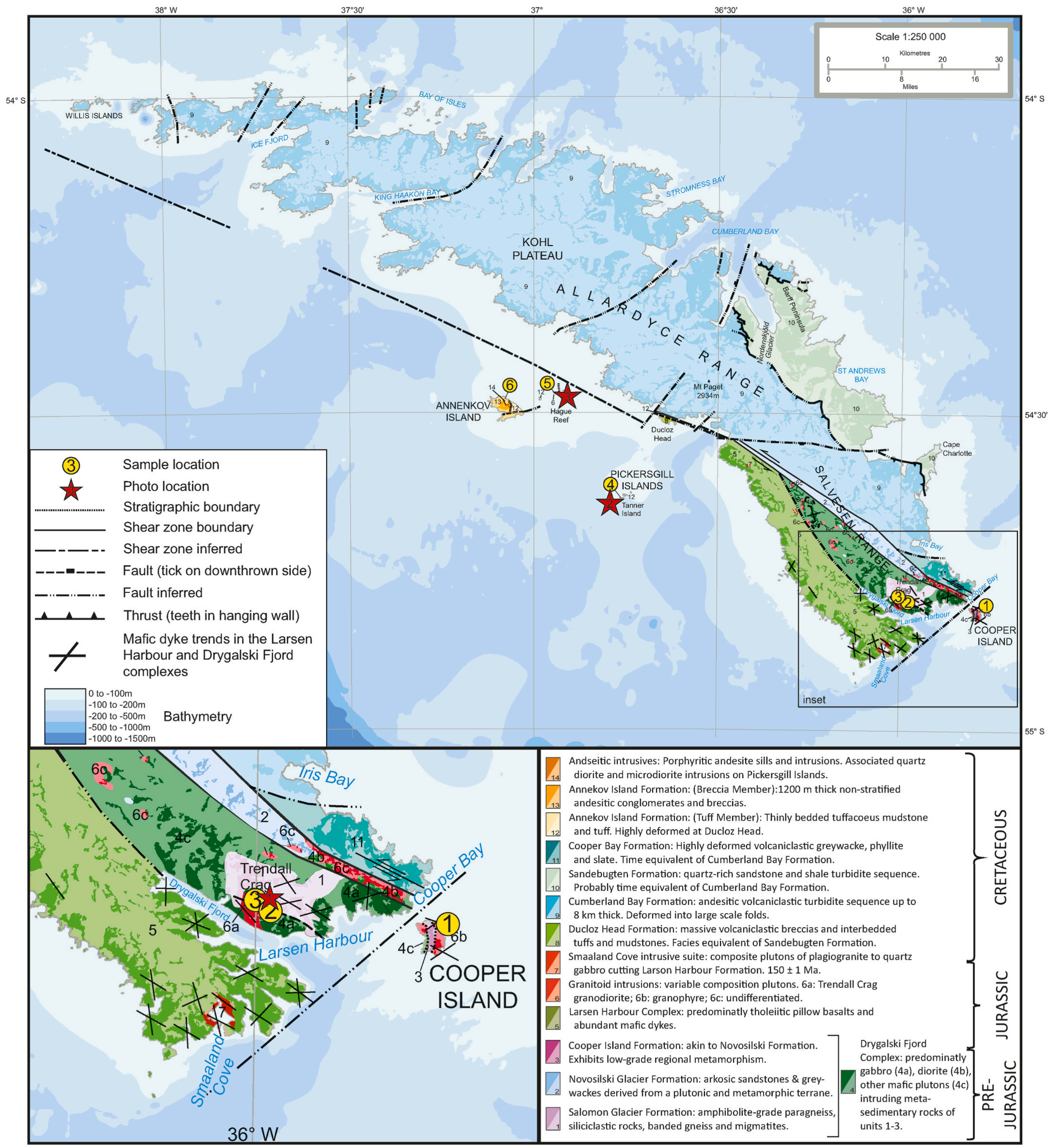

Fig. 3. Geological map of South Georgia. Modified from Curtis (2011). Sample locations, 1. M.1653CMB2.1 (Cooper Island: 54.80261° S, 035.80442° W), 2. M.1804.1 (Trendall Crag: 54.79266° S, 035.98078° W), 3. M.4137.3 (Trendall Crag: 54.78945° S, 035.97981° W), 4. M.2375.5 (Pickersgill Islands: 54.62890° S, 036.76278° W), 5. M.2365.1 (Hague Reef: 54.46745° S, 036.94038° W), 6. M.1189THP.1 (Annenkov Island: 54.47579° S, 037.06932° W). Photo locations (star symbol) refer to 1: Trendall Crag (Fig. 4); 2: Pickersgill Islands (Fig. 5); 3: Hague Reef (Fig. 6).

Fig. 4. Dolerite dykes cutting layered gabbro at Trendall Crag (Drygalski Fjord Complex) associated with granite-granodiorite dated as part of this study. Hammer is 80 cm in length. Image from B.C. Storey.

Pb analysis. Both samples are medium-to coarse-grained granitoids (granite-granodiorite) that are associated with layered gabbros and cut by multiple dolerite dykes (Fig. 4). The intrusive rocks form part of the Drygalski Fjord Complex that is a suite of gabbroic and granite/granodiorite plutons that intrude the metasedimentary rocks/paragneiss units of the Salomon Glacier Formation and associated successions of the Novosilski Glacier and Cooper Island formations.

Sample M.2375.5 is a medium-grained granite from the westernmost of the Pickersgill Islands (Tanner Island; Fig. 3). Tanner Island is formed of a composite intrusion that is mainly quartz monzodiorite but also includes granite and quartz monzonite (Fig. 5), that is cut by rare dolerite and aplite dykes. The granite, selected for analysis here, is quartz-plagioclase-K-feldspar-biotite bearing and is host to rare dioritic xenoliths. Carter et al. (2014) reported an apatite fission track age of c. 89 ± 5 Ma for this sample.

Sample M.2365.1 is a leucocratic porphyritic microgranite from the central island of Hague Reef (Fig. 3). Hague Reef is a linear chain of small islands and rocky shoals between Annenkov Island and the main island of South Georgia (Tanner et al., 1981). The central island is dominated by volcaniclastic sediments and crystal tuffs of the Annenkov Island Formation (Fig. 3) that are cut by multiple plug-like bodies of biotite- and hornblende-andesite. The intrusions are typically fine-grained andesite/diorite, but rare coarse-grained units are evident that have higher quartz contents, including the microgranite selected for analysis here. (Fig. 6).

Sample M.1189THP.1 is a fine-grained quartz diorite from northeast Annenkov Island (Fig. 3) that intrudes mudstones and tuffs of the Annenkov Island Formation (Pettigrew, 1981). The quartz diorite is leucocratic with abundant plagioclase set in a finer-grained groundmass and has yielded an apatite fission track age of c. 81 ± 4 Ma (Carter et al., 2014).

Fig. 5. Granitoids exposed along the eastern coastline at Tanner Island (Pickersgill Islands). Image from B.C. Storey.

Fig. 6. Microgranite exposed at Hague Reef. Figure is 1.7 m in height. Image from T.H. Pettigrew.

5. Analytical methods

5.1. U-Pb zircon geochronology

Zircon (U-Pb) geochronology was carried out at University College London with full data and standards tables provided in the supplementary files (Supplementary Table S1).

Heavy minerals were separated from bulk sieved (<300 μm) crushed rock using standard density liquid and magnetic separation procedures. Zircon-enriched extracts were mounted in hard epoxy resin on glass slides and polished for analysis. Zircon crystals are typically in the size range 120–200 μm, with a range of grain sizes analysed for all samples. Zircon U-Pb geochronology on all six samples was carried out at University College London (November 2023) using laser ablation inductively coupled mass spectrometry (LA-ICP-MS) facilities (Agilent 7700 coupled to a New Wave Research 193 nm excimer laser) at the London Geochronology Centre. Typical laser spot sizes of 25 μm were used with a 7–10 Hz repetition rate and a fluence of 2.5 J/cm^2 and the outer parts of the grain were analysed with spots selected from reflected light imagery. Background measurement before ablation lasted 15 s and laser ablation dwell time was 25 s. The external zircon standard was Plešovice, which has a TIMS reference age 337.13 ± 0.37 Ma (Sláma et al., 2008). Standard errors on isotope ratios and ages include the standard deviation of $^{206}Pb/^{238}U$ ages of the Plešovice standard zircon. Time-resolved signals that record isotopic ratios with depth in each crystal were processed using GLITTER 4.5, data reduction software, developed by the ARC National Key Centre for Geochemical Evolution and Metallogeny of Continents (GEMOC) at Macquarie University and CSIRO Exploration and Mining. Processing enabled filtering to remove spurious signals owing to overgrowth boundaries, weathering, inclusions, or fractures. Discordance was determined using ($^{207}Pb/^{235}U$ - $^{206}Pb/^{238}U$)/$^{206}Pb/^{238}U$) and similar for $^{207}Pb/^{206}Pb$ ages using a discordance distance filter threshold in the range −2 to 7 (Vermeesch, 2021).

6. Results

6.1. U-Pb zircon geochronology

Sample M.1653CMB2.1 from Cooper Island (Fig. 3) yielded stubby prismatic zircons 100–150 μm in length with aspect ratios of 1.5–2:1. Twenty separate zircon grains were analysed with just one discordant grain (Fig. 7a) resulting from likely Pb loss. The Cooper Island tonalite yields a weighted mean $^{238}U/^{206}Pb$ age of 159.7 ± 0.8 Ma, overlapping with the concordia age.

Sample M.1804.1 from Trendall Crag yielded prismatic zircons up to 200 μm in length with aspect ratios up to 4:1 and a concordia age of 162.0 ± 0.9 Ma (weighted mean $^{238}U/^{206}Pb$ age of 162.3 ± 1.0 Ma) is calculated (Fig. 7b) from 19/25 grains analysed, with three likely inherited grains (>175 Ma) and three outside the discordance distance filter of −2 to 7 (Vermeesch, 2021) that were subject to Pb loss. A second granitoid sample (M.4137.3) from Trendall Crag (Fig. 3) was also analysed, which is characterised by stubby, prismatic zircons up to 150 μm in length and a minor population of more rounded grains. Sample M.4137.3 defines a concordia age (165.0 ± 0.6 Ma; Fig. 7c) broadly consistent with M.1804.1 (Fig. 7b). The age is based on 37 analyses, with nine analyses not included in the age calculation as they represent inherited grains (Supplementary Table 1) from the Early Jurassic, Palaeozoic and Mesoproterozoic or fall outside the discordance filter as a consequence of recent Pb loss.

Sample M.2375.5 from Pickersgill Islands (Fig. 3) is characterised by prismatic zircons up to 150 μm in length and aspect ratios of 3:1. M.2375.1 yields a concordia age of 86.2 ± 0.6 Ma (identical to the weighted mean $^{238}U/^{206}Pb$ age) from 18/22 grains analysed (Fig. 7d) with three inherited grains excluded (>94 Ma) and two values that fall outside the discordance distance threshold.

Sample M.2365.1 from Hague Reef (Fig. 3) is characterised by stubby prismatic grains, typically 150–200 μm in length and aspect ratios up to 3:1. They have pale centres and darker areas in the grain terminations. M.2365.1 yields a weighted mean age of 163 ± 2 Ma (Fig. 7e) based on 17/20 analyses, with one grain likely to have been subject to Pb loss, one discordant grain and a single inherited grain (>173 Ma).

Sample M.1189THP.1 from Annenkov Island (Fig. 3) is a microdiorite that contains prismatic zircon grains up to 150 μm in length. M.1189THP.1 yields a moderately well constrained concordia age of 107.5 ± 0.4 Ma (Fig. 7f), but with spread along concordia. The calculation is based on 10/12 zircon grains with two discordant grains not included in the calculation.

6.2. Age summary

The granitoids of South Georgia yield relatively well constrained ages that range from mid-Cretaceous to Middle Jurassic. All samples are characterised by a spread of ages that include inherited zircon grains,

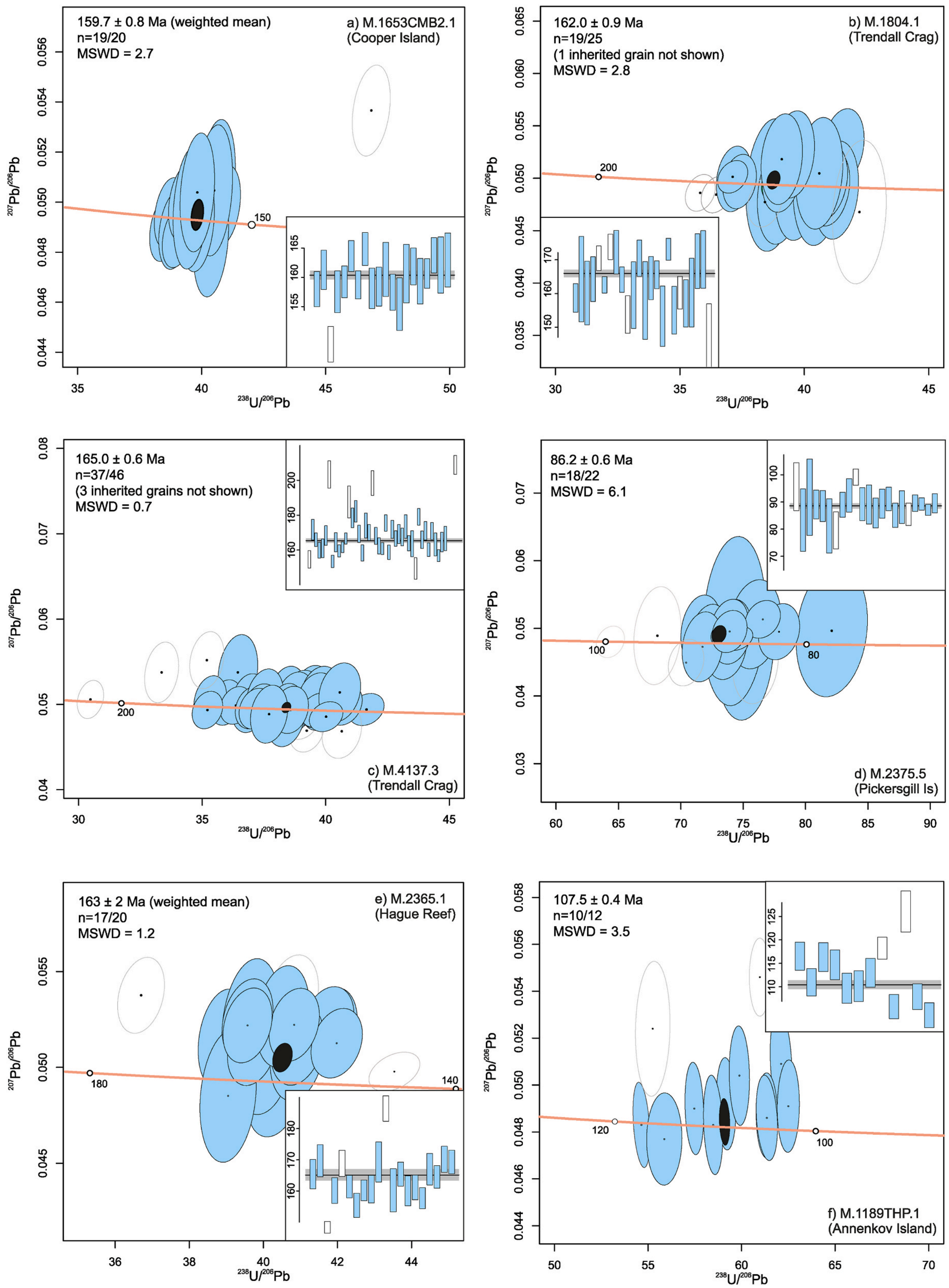

Fig. 7. U-Pb zircon Tera-Wasserburg concordia and weighted mean plots for granitoid rocks from South Georgia. Reported ages are concordia ages except where stated otherwise.

recent Pb Loss and discordance between $^{235}U/^{207}Pb$ and $^{238}U/^{206}Pb$ ages. Granitoids from Trendall Crag, Cooper Island and Hague Reef all yield ages in the range 165–160 Ma, which are typically characterised by a minor population of inherited grains at c. 175 Ma, coincident with the Tobífera Formation of southern Patagonia and the V2 event of Pankhurst et al. (2000), particularly in the two samples from Trendall Crag.

Two samples from the outlying islands (Pickersgill Islands and

Annenkov Island) yield mid-Cretaceous ages, which are also characterised by a minor population of inherited (antecryst) zircons from an earlier mid-Cretaceous episode of magmatism that are marginally older than the crystallisation age.

7. Discussion

Our new U-Pb granitoid geochronology, combined with existing dating from South Georgia now enables a complete chronology of magmatic events to be established (Fig. 8a). The initial phase of magmatism developed in the Middle Jurassic (c. 160–165 Ma) with granitoids of the Drygalski Fjord Complex from the Cooper Bay shear zone and at Trendall Crag (Fig. 3) emplaced in this interval. Middle Jurassic granitoid emplacement has also been identified from Hague Reef (Fig. 3) to the west of South Georgia where a microgranite records an age of 163 ± 2 Ma.

This episode of Middle Jurassic magmatism is also recognised across the potentially contiguous Cordillera Darwin (Fig. 8a), which records granitic magmatism at 164 ± 2 Ma (Mukasa and Dalziel, 1996). This age is also recorded (c. 163 Ma) in the detrital zircon age profile of Jurassic clastic rocks of the Cordillera Darwin (Hervé et al., 2010).

Riley et al. (2026)suggested that the Cordillera Darwin and South

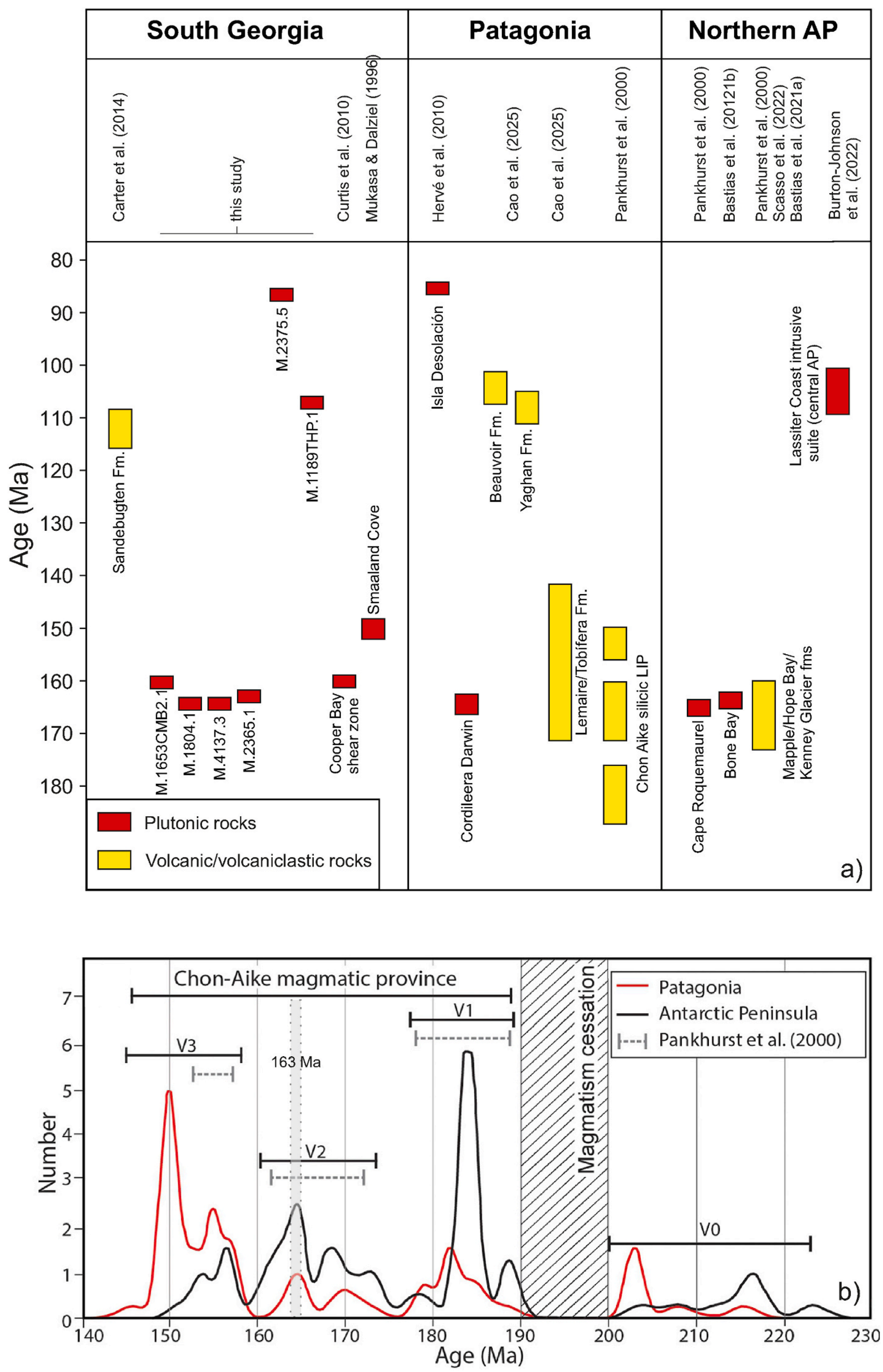

Fig. 8. a) Summary of magmatic ages from South Georgia, Fuegian Andes (Patagonia) and the northern Antarctic Peninsula. b) Age histogram of early Mesozoic magmatism from Patagonia and the Antarctic Peninsula (Bastías et al., 2021a,b).

Georgia may have been adjacent to the northern Antarctic Peninsula during the late Palaeozoic/early Mesozoic, therefore it is of value to also examine the extent of Middle Jurassic magmatism across the northern Antarctic Peninsula. Volcanism associated with the Chon Aike silicic large igneous province is widespread across the northern Antarctic Peninsula (Pankhurst et al., 2000), including the Kenney Glacier Formation and correlatives of the Mapple Formation (Riley et al., 2010). Pankhurst et al. (2000), Riley et al. (2010), Bastías et al. (2021a) and Scasso et al. (2022) all reported ages in the range 173–160 Ma for mostly rhyolitic tuffs and ignimbrites but also including isolated granitoid ages from the northern Antarctic Peninsula. Bastías et al. (2021a) identified a peak in magmatic ages at c. 163 Ma in the interval 173–160 Ma, also identified (c. 165 Ma) by Riley et al. (2010) in the detrital zircon record of Late Jurassic sedimentary rocks from Jason Peninsula (Fig. 1a). The highest precision ages of magmatism from the northern Antarctic Peninsula were carried out by Scasso et al. (2022) who used CA-ID-TIMS to determine U-Pb zircon ages from volcanic tuff beds in the Mount Flora Formation that underlies the Kenney Glacier Formation at Hope Bay (Fig. 1a). They determined ages of 163.55 ± 0.06 Ma that are consistent with the ages (Fig. 8a) of Pankhurst et al. (2000), Riley et al. (2010) and Bastias et al. (2021a, 2021b). There are relatively few granitoid ages from the northern Antarctic Peninsula, with Pankhurst et al. (2000) reporting ages of c. 164 ± 2 Ma from Cape Roquemaurel (Fig. 1a) on the northern coast of the Antarctic Peninsula and Bastias et al. (2021b) determined an age of 163 ± 2 Ma from a granite at Bone Bay (Fig. 1a) adjacent to Cape Roquemaurel. Bastías et al. (2021a) also determined several ages in the interval 160–165 Ma from volcanic and plutonic units from eastern Graham Land (Fig. 8a) demonstrating the ubiquity of magmatism in this interval across the northern sector of the Antarctic Peninsula.

In contrast, the southern sector of Patagonia is dominated by Late Jurassic magmatism (c. 155 Ma) and components of the Tobífera Formation dated at 172 ± 1 Ma (Pankhurst et al., 2000). However, there are still multiple occurrences of magmatism in the interval 160–165 Ma, with isolated granitoids and volcanic rocks from the Cordillera Darwin dated in the interval c. 165–160 Ma (Mukasa and Dalziel, 1996; Cao et al., 2025), as well as evidence in the detrital zircon record (Hervé et al., 2010).

This distribution of magmatism in the interval 160–165 Ma is consistent with the interpretation of Riley et al. (2026) that South Georgia (Drygalski Fjord Complex), the northern Antarctic Peninsula and Cordillera Darwin share a common geological history from at least the late Permian, with a likely contiguous relationship. Magmatism in this interval overlaps with the refined V2 (173–160 Ma) event (Bastías et al., 2021a) and is considered to have developed in a convergent margin setting that can now include South Georgia.

Granitoid magmatism away from the Drygalski Fjord Complex exhibits a broader age range. Magmatism at Smaaland Cove (150 ± 1 Ma; Mukasa and Dalziel, 1996) is Late Jurassic in age, whilst magmatism on Pickersgill Islands (87.2 ± 0.3 Ma) and Annenkov Island (107.5 ± 0.2 Ma) are mid- Late Cretaceous in age, consistent with the K-Ar ages determined by Tanner and Rex (1979). The tonalite intrusion at Smaaland Cove dated at c. 150 Ma (Mukasa and Dalziel, 1996) coincides with a significant age peak (150 ± 2 Ma) in magmatism identified in Patagonia (Hervé et al., 2007; Bastías et al., 2021a; Cao et al., 2025).

Mid-Cretaceous magmatism in Annenkov Island has been dated at c. 107 Ma and is coincident with widespread granitoid magmatism along the proto-Pacific margin of Gondwana through the southern Andes, Patagonia and Antarctic Peninsula (e.g. Paterson and Ducea, 2015; Riley et al., 2018; Burton-Johnson et al., 2022; Bastías et al., 2023; Cao et al., 2025). Riley et al. (2018) and Burton-Johnson et al. (2022) defined three separate pulses of mid-Cretaceous magmatism, including a distinct episode in the interval 102–109 Ma, coincident with the phase of magmatism on Annenkov Island. Analysis by Paterson and Ducea (2015) and Bastías et al. (2023) also highlighted the primary age peak across the southern Andes was in the interval 108–112 Ma, again broadly coincident with magmatism on Annenkov Island.

The youngest phase of magmatism identified across South Georgia is from Pickersgill Islands at 86 ± 1 Ma. Magmatism in the interval 80–90 Ma is rare across the northern Antarctic Peninsula, with isolated ages from the South Shetland Islands (Leat and Riley, 2021) defined by K-Ar methods. However, Hervé et al. (2007) identified a distinct phase of magmatism at 85 ± 1 Ma (Fig. 8a), including granodiorite on Isla Desolación forming part of the Cordillera Darwin terrane, south of Magallanes Fault Zone (Fig. 1a).

Overall, the magmatic record of South Georgia aligns well with the chronology of magmatism across the northern Antarctic Peninsula and the South Patagonian batholith of the Cordillera Darwin, and further west towards Isla Desolación (Fig. 1a). In all cases, the youngest episodes of magmatism are from the western sectors of the southern (Fuegian) Andes, the Antarctic Peninsula and South Georgia.

8. Summary

- Granitoid magmatism has been identified from South Georgia spanning several separate intrusive episodes from the Middle Jurassic (c. 160–165 Ma) and Late Cretaceous (c. 107 Ma and c. 86 Ma).
- The Middle Jurassic granitoid episode is widespread across the southern and western sectors of South Georgia, whereas the Late Cretaceous magmatism is restricted to the outlying islands to the west of the island.
- The chronology of magmatism across South Georgia is replicated across the northern Antarctic Peninsula and the southern Patagonian (Fuegian) Andes, and supports a close association during the early Mesozoic between South Georgia (Drygalski Fjord Complex), Tierra del Fuego and the northern Antarctic Peninsula
- A similar close relationship is supported in the detrital zircon record of the accretionary complexes of South Georgia, southern Patagonia and the northern Antarctic Peninsula. As well as the ophiolite units of the Larsen Harbour Complex and across the Cordillera Darwin.

CRediT authorship contribution statement

Teal R. Riley: Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization. **Andrew Carter:** Writing – review & editing, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Teal Riley reports statistical analysis was provided by UK Research and Innovation Natural Environment Research Council. Teal Riley reports a relationship with British Antarctic Survey that includes: employment. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jsames.2025.105882.

Data availability

The data that support this research are all available as supplementary files linked to this article. Full datasets are also hosted at the British Antarctic Survey's Polar Data Centre https://doi.org/10.5285/aeac83d8-b368-4152-9083-5956b84e348e.

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